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America

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RUBBER PLANTING IN MEXICO AND CENTRAL AMERICA.

By PEHR OLSSON—SEFFER, Ph.D.

Introductory.

Very little has been said or published so far about rubber planting in Mexico and Central America. So little, in fact, that people generally do not seem to know that anything is done in those countries as regards rubber, except a few erratic attempts at cultivating that much despised *Castilla* rubber tree. A short time ago I met a Ceylon planter in Japan. When our conversation turned towards rubber and I had received many tales about Ceylon, I volunteered the information that we had one or two plantations also in Mexico. He was highly surprised.

A desire to dispel some similar views, which I have found in Singapore, has tempted me to publish this article, which partly consists of some advance sheets from my small handbook, "Cultivation of the *Castilla* Rubber Tree," now in the printer's hands, and partly of data obtained from my first Annual Report from La Zacualpa Botanical Station and Rubber Laboratory, which is soon to go to press. I have added some reflexions which will perhaps give this article a rather pronounced tendency, and I have advanced some ideas which all of the Mexican planters are not yet ready to entertain.

The Name "Castilla."

I wish first to explain why I am persistently using the generic name *Castilla*, instead of *Castilloa*, to which most persons are accustomed. I go on the principle that everything should be called by its true name. The right name of the Central American rubber tree is *Castilla*. It was first described and named by the botanist *Cervantes* in 1794, and the description was printed the same year in "Suplemento à la Gaceta de Literatura." It is here written *Castilla*, and the tree was named thus in honour of the Spanish botanist *Castillo*, who had died the previous year, while he was working on a flora of Mexico. In 1805 an English translation of the paper was published anonymously, and now the name was changed to *Castilloa*. The translator (who is believed to have been CHARLES KOENIG, the keeper of the mineralogical department of the British Museum) had no right to alter the name. A Mexican botanist had already, with just as little right, proposed to change the name to *Castella*, shortly after the plant had been described. Now we have in systematic botany certain recognized rules of nomenclature, and one of these is that of priority. As *Castilla* was the first name given, it should remain so. This question was discussed and settled in 1903 by O. F. COOK, in "The Culture of the Central American Rubber Tree" or Bulletin No. 49, Bureau of Plant Industry, United States Department of Agriculture, but it seems to have been overlooked.

Different Forms of Castilla.

Another question which is causing considerable misconception as regards our Central American rubber tree is that of species. *Castilla elastica* Cerv. in a very wide species, containing numerous forms. A species-making botanist could easily divide it into a dozen species or more. I have personally observed nine fairly distinct forms, but I still hesitate to recognize them as good varieties. KOSCHNY, a Costa Rica planter, who has written considerably in "Der Tropenpflanzer" about *Castilla* in certain parts of Central America, speaks of several "species," but does not give satisfactory descriptions that would warrant his forms to receive the distinction of species. COOK described the form occurring on and near La Zacualpa rubber plantation in Soconusco, Mexico, as a new species, *C. lactiflua*. In Hawaii I saw a form planted from seeds obtained from a seed merchant in Paris under the name var. *nicaraguensis*. It certainly was different from any other form I have seen elsewhere. *C. markhamiana* is generally considered to be a separate species, and the *Castilla* grown in Ceylon is sometimes referred to as this species. Certain is that the Ceylon *Castilla* is not identical to any Mexican *Castilla* that has come under my notice.

From the planter's point of view it is of little significance whether one or more species are cultivated so long as the rubber is obtained. But it is in this fact of the existence of many different forms in which we have to find an explanation of the reputed failure of *Castilla* in different places, where its success had been presupposed.

If we plant seeds of the *Castilla* of the Atlantic side of Southern Mexico, with an almost continuous rainfall, on the Pacific slope of the Sierra Madre, where we have a distinct dry season of six months, the tree does not succeed in growth, the amount of latex is smaller, and a planter would soon find out that he had made a great mistake, had he tried this experiment on a large scale. It seems to me probable that if attention had been paid to this ircumstance, *Castilla* would be more of a favourite than it is.

We are working on this problem at La Zacualpa Botanical Station. Herbarium specimens are secured of *Castillas* from various parts of Central America, and seeds of different varieties are being planted in the experimental plots. In due time we expect to be able to throw some light on this question. Seeds of our local *Castilla lactiflua* have been sent to various places in the West Indies, to British Guiana, Gold Coast and other places in West Africa, Ceylon, Java, Queensland, Philippines and Hawaii, and I expect to obtain reports upon the progress and development of the plant under the different conditions prevailing in these different countries.

The Geographical Distribution of Castilla.

Castilla grows wild from 21° north latitude in Mexico southward through Guatemala, Honduras, San Salvador, Costa Rica, Nicaragua, Panama, and also in North-Western South America. The area in Mexico is a belt ranging from ten to one hundred miles in width and extending from the port of Tuxpan in the north to the western boundary of Campeche, a distance of about 500 miles. The extent of the rubber belt is also rather small in Central America, where it can be said to follow the Cordilleras on both sides, while in South America it grows on the western slope of the Andes of Equador and Peru.

Castilla rubber is generally known in the market as "Centrals" but it derives many other names from the countries and localities in which it is found growing. Thus it is called Peruvian caucho, Guayaquil rubber, Barranquilla, Darien, Panama, Cartagena, Honduras, Nicaragua, West Indian, Guatemala, and Mexican rubber.

The most common species is *Castilla elastica* Cervantes, but other species such as *C. markhamiana* and *C. tunu* occur in different regions. The question of the geographical distribution of the various representatives of the genus *Castilla* is not yet sufficiently investigated.

On the Isthmus of Panama the *Castilla* is quite common in some districts. Mr. Cross writes about its occurrence in this country:—

"The Caucho tree grows not in inundated lands or marshes, but in moist, undulating, or flat situations, often by the banks of streamlets and on hillsides and summits where there are any loose stones and a little soil. It is adapted to the hottest parts of India, where the temperature does not fall much below 74° F. The tree is of rapid growth, and attains a great size, and I am convinced that when cultivated in India, it will answer the most sanguine expectations that may have been formed concerning it. I have been up the Chagres and Gatun rivers. I came out on the railway about seven miles from Colon. I go back to the same place (the village of Gatun) from which place by the river the India-rubber forests are reached."

As to *Castilla* in Costa Rica, Mr. T. F. Koschny states:—

"The safest and most productive rubber plant is the *Castilloa elastica* of Central America. Its tenacity of life and adaptability to soil and climate are seldom exceeded by other trees; the same is also true of the quantity and quality of the rubber."

"It requires a humid, warm climate, and with respect to rainfall less depends upon the amount of precipitation than upon the distribution of it. The shorter the dry season and the more the rain extends over the entire year the better will the locality be adapted for rubber culture; regions with a long, absolutely dry season are unsuitable for this culture. In the valley of San Carlos, Costa Rica, upon the Atlantic slope, it rains occasionally also in the dry season, and even in the two dryest months, March and April. The Pacific slope of Central America has, on the contrary, a completely dry season of four months, and two months at the beginning and end with little rain. Both the wild and the planted rubber trees die there at the third tapping at the latest, in case this takes place in the dry season."

Colins writes in his Report on the Caoutchouc of Commerce, in regard to the occurrence of *Castilla* in Nicaragua:—

"The basin of the Rio San Juan is where the Ule tree grows to perfection. This river is the natural vent of the two vast basins of the lakes of Nicaragua and Managua, receiving numerous tributaries, which have all their sources in the innumerable tracts hitherto virgin and unfrequented, and where the trees abound. The ground is very fertile. The district is very unhealthy."

Rubber Planting in Central America.

Throughout the Central American republics very little has as yet been done towards planting rubber. In most of these countries there is a great unstability of government, and foreign capital is not attracted under such conditions. Labour conditions are also very unsatisfactory on account of the frequent revolutionary movements, which sporadically crop up and draw the greater part of the able-bodied men to the ranks either of Government or rebel armies. Transportation also offers a serious drawback, and many prospective planters are deterred from settling because of the reported unhealthfulness of the climate. This latter is not worse than in other tropical countries, and with the advent of the Pan-American railroad, which will connect the south with the north, the country will be opened. In Central America there is plenty of land suitable for rubber planting. A year ago I rode for days through good rubber country in Guatemala.

In this latter republic very little planting of rubber has so far been done. In Northern Guatemala there is only one plantation of any account devoted to rubber. In the other Central American States, rubber cultivation has been commenced on a small scale. In Nicaragua there are a number of plantations, especially near the Pearl Lagoon, on the Bluefields and Escondido rivers. In Panama rubber is being planted, in Costa Rica there are a few young plantations, and in Honduras rubber has been planted as shade for cacao. In San Salvador some rubber has recently been planted. Altogether there are in the Central American republics as far as I know 12,230 acres under rubber.

During the year 1904 the first attempts at collecting latex from cultivated trees were made in Nicaragua. These experimental tappings were made on a plantation about thirty miles north of Bluefields in the Pearl Lagoon district. The plantation is one of the oldest in the country and belongs to an American, Mr. J. C. Horter. The trees tapped were raised in a nursery in 1897, transplanted in 1898, and in 1904, at an age of seven years, they measured 17 to 30 inches in girth and 40 to 45 feet in height. Of the 6,000 trees that were tapped the largest received three incisions, the medium-sized two incisions, and the small ones only one. The average amount of rubber per tree was one and a half ounce. Careful attention was given to the collecting and the rubber obtained was of a greater value than the ordinary "Nicaragua syrup," as the rubber of that district is commercially known. A few of the largest trees were tapped repeatedly at intervals of two weeks without apparent injury, and they yielded each time almost the same amount of rubber.

The Government of Nicaragua, a few years ago, issued a decree offering a premium of ten cents for every rubber tree planted, when the number does not go below 250 trees planted by any one person. The decree provides that the trees must be planted sixteen feet apart. Very few planters have, however, seen fit to accept this offer.

According to recent press reports the devastating cyclone, which visited Central America a few months ago destroyed most of the Bluefields plantations. It is estimated that some 450,000 well developed trees were thus broken and uprooted.

In August, this year, the Government of the Republic granted a concession to a syndicate for the revenue from the exportation of crude rubber from the Department of Zelaya and the districts of Prinzapolca and Great River. This concession is for ten years, and among other requirements from the concessionaries there is one that they are obliged "to employ only expert rubber cutters "who strictly comply with the requirements of Article 11 of the "Regulations of October 15, 1901, which say: 'It is prohibited to "make incisions into the trees to the extent of penetrating the "woody part. Incisions of more than one-half of the circumference "of the trunks or limbs of the trees are also prohibited.' The "contravention of this article shall be punished by a fine of $5 for "every tree damaged." On account of this concession it is now required that a planter who wants to export his rubber, must produce at the custom house a certificate from the authorities of the district where the plantation is situated specifying the locality whence the rubber comes. The Government of Nicaragua has imposed a tax of 5 cents on every pound of rubber exported from the country.

In the value of exports rubber appears as the fourth. All of this is collected from wild trees. The amount shipped from San Juan del Norte to United States in 1905 was 473,389 pounds.

On the cacao estates in the Rivas district rubber trees have been planted as shade. In Costa Rica rubber has not proved a success as shade for cacao. In this latter country rubber is cultivated near the coasts and on the Nicaragua frontier. Several varieties of *Castilla* are grown, but the plantations are not yet in bearing, so that definite results as to the yield of these forms are still uncertain. In 1905 about 160,000 pounds wild *Castilla* rubber was exported from this country.

Planting in Mexico.

One of the first attempts to cultivate rubber in Mexico was made by the Hon. MATIAS ROMERO, who in 1872 planted 100,000 trees near Suchiate River in Soconusco, on the Guatemalan border. The owner had to abandon the place for political reasons and the plantation was gradually destroyed by native rubber collectors and by fire, so that at present there is hardly any trace left. On the identical spot of the old plantation a new one has been started in recent years by a relative of Señor ROMERO. When I visited the place, about a year ago, it was in a thriving condition. Some thirty years ago Don EUGENIO SANCHEZ on the Teapa river in the State of Tabasco planted the first rubber trees. After that the PRATT and ALFARO families planted rubber, and about 22 years ago most of the farmers in the Teapa and Pichucalco valleys commenced to plant extensively. For the past twelve years there has been a steady increase of the planted area. In the Rio Seco Valley, DON AUGUST LITZOFF has now about 100,000 trees, two to nine years old.

On the upper Grijalva, above Huimanguillo, there is a line of farms for about 30 miles; most of these are tapping 10 year old trees. Señor ABALOS, of Huimangillo, cropped an average of 14 ounces rubber from his 10 year old trees last year.

All this was done on a comparatively small scale, however, the plantations being in Mexican hands not consisting of more than a few thousands or tens of thousands of trees. About 18 years ago a number of rubber trees were set out as shade for cacao on La Zacualpa, in Soconusco, by the then owner Señor PALAEZ. Of these there are some 1,000 trees left, and they have been regularly tapped for many years, the trees now presenting a very scarred appearance as a result of the primitive method of tapping employed by the native huleros.

Less than ten years ago American capital was attracted towards rubber planting in Mexico. As a result of this movement we have to-day approximately 100 plantations, entirely or partly devoted to rubber. I have in my possession letters and data showing that the whole area under rubber in Mexico to-day (December 1, 1906) is at least 82,620 acres. I think it is safe to say 90,000 acres. Next year's planting, at a low estimate, will be 10,000 acres. In this total I have not included what "has been" planted, but is no more. And I do not believe the entire area mentioned above can be counted upon to become producing.

In order to explain this I have to mention that it is estimated that this area under rubber represents at least £6,000,000, that are nominally invested in rubber plantations. A considerable part of this money has never reached Mexico, but has been squandered by promoters in America. A very large amount has also been lost through the ignorance of many so-called planters and plantation managers.

Rubber Cultivation in the Experimental Stage.

While I am willing to admit that rubber culture has passed the experimental stage so far as the possibility of producing rubber is concerned, it cannot be denied that in regard to proper agricultural methods this industry is still in its undeveloped childhood.

It has been clearly demonstrated in the progress of many agricultural industries, that very little advance is made before the persons concerned have learned to appreciate the value of co-operation for the purpose of comparing their individual experiences and to take advantage of knowledge gained by previous experiments. Among the rubber planters and plantation managers in Mexico and Central America there is no co-operation whatever. Everyone is satisfied that he has employed the right methods of planting, although in most cases he started in without any previous experience. The correct methods are by no means ascertained beyond any question of doubt at present. But if a person visits a great number of plantations in different districts or countries, he cannot fail to observe some of the advantages or disadvantages of the various methods employed.

We may be able to advance certain theories regarding planting operations, we know that the rubber tree under certain conditions will grow well, we may be able to extract and prepare a certain amount of rubber from the trees, but we cannot yet say which method of growing rubber will give the largest possible return, we do not know whether the most rapid grower is the best producer, and in regard to the manner of obtaining the rubber we still remain on a very primitive footing.

The experimental era of rubber culture, instead of being short and inexpensive, is growing too long for these modern times and it has certainly been unnecessarily costly. Where the experiments should have been conducted on a small scale by persons specially prepared to do this kind of work, the whole *Castilla* planting industry has been one colossal experiment, in which millions of money have been staked on the integrity, possible intelligence, and probable good fortune of men, who in many instances have lacked every experience of tropical planting, and in some cases had not even been in the tropics before undertaking the management of a plantation. Millions have thus been literally thrown away, companies have gone bankrupt, and plantations have been abandoned. Those that have survived up to the present time will in due course become a success, at least in the majority of cases. Exaggeration has been the keynote in the promoter's circulars, and inexperience the cause of most failures.

Some Mexican Plantations.

I have in a previous publication (Bulletin II, La Zacualpa Botanical Station, "Notes on Rubber Culture in Mexico") tentatively divided Mexico into a number of rubber districts, the northernmost being that of Tierra Blanca, in the State of Vera Cruz. The number of plantations in this district is small. Among these may be mentioned Hacienda Yale, owned by a number of former students of Yale University, and La Esperanza, first started by Mr. Geo. Cullen Pearson, representing British capital.

Not far from Perez station on the Vera Cruz and Pacific railroad is the Playa Vicente district, containing several small plantations. In this neighbourhood, along the Papaloapan river, are a number of other rubber plantations which all can go under the name of the Tuztepec district.

Further south, and not very far from Santa Lucrecia we have the important Trinidad River district. This is often included in the general term of "the Isthmus," but conditions are in many respects differing from those on the Isthmus proper. This latter is a very large district comprising the rubber country along the National Tehuantepec railroad, and along the Coatzacoalcos river or its tributaries.

One of the largest plantations on the Isthmus is Rubio, situated some distance from the township of Minatitlan. It is owned by the Tehuantepec Rubber Company of New York. Its able manager is Mr. A. B. Luther, who has had a long Merican experience, and also has studied conditions in the South American rubber districts. Rubio plantation has some 3,000 acres under rubber. Oaxaqueña, Colombia and Del Corte are some of the other larger rubber plantations in the district.

In the Trinidad River district the largest plantation is La Junta, owned by the Mexican Mutual Planter's Association, of Chicago. It has some 4,500 acres under rubber besides a large acreage in coffee and cacao. Its manager is Mr. J. C. Harvey, who also is part owner of an adjoining rubber plantation, Buena Ventura. Here Mr. Harvey, who is very much interested in botany, has a small botanic garden of his own, the only one, in fact, in the country. Some fifty different species of palms, a good sized collection of native and foreign orchids, many economic plants, and ornamental trees and shrubs surround his house. The only Para trees yet grown in Mexico are to be found here, and are Mr. Harvey's special treasures. Many of the trees and plants in this collection are raised from seeds obtained from Singapore Botanic Gardens, with the Director of which Mr. Harvey is in frequent correspondence.

Another very extensive rubber district is situated along the Grijalva river, and the Usumacinta river system constitutes a district covering a large area. Lastly on the Pacific slope of Chiapas, between the towns of Pijijiapan and Tapachula, we have the Zacualpa district, very limited in area.

Some eighteen years ago *Pelaez*, then owner of La Zacualpa, in Soconusco, planted rubber as shade for cacao, and of these trees a number are still left and are being tapped every year. In 1899 Mr. O. H. Harrison, a coffee planter, bought Zacualpa and immediately commenced planting rubber. The plantation which was later transferred to La Zacualpa Rubber Plantation Company, of San Francisco, California, is now probably the largest individual rubber plantation in the world, and will when ultimately completed consist of 12,000 acres under rubber. The variety grown is *Castilla lactiflua* Cook. In 1905 the first tapping from young trees was done, some 25,000 trees, between five and six years old, being lightly tapped. Six other rubber plantations have been started of late years in this district, two of which, Juilapa and Zacualpa II, are also under the general direction of Mr. Harrison. These three sister plantations have now over 8,000 acres under rubber, varying in age from 6 months to 6½ years.

In order to show how rubber planting is done in Mexico, and how we expect to handle the plantations and the crop of latex and rubber, I will describe somewhat in detail the conditions on La Zacualpa, and the methods which the management at my suggestion intends to adopt for the future.

La Zacualpa Rubber Plantation.

The estate which consists of 18,791 acres of land is situated on the coastal plains between the Sierra Madre and the Pacific Ocean, about twelve miles from the latter. The land slopes very gently towards the ocean, and the highest spot of the rubber plantation is about 50 feet above sea level. Two small rivers flow on the outskirt of the estate, which is intersected by several creeks. Part of the land is swampy, and is not planted in rubber.

The plantation is laid out in square blocks, each containing 27¾ acres. There are now over 200 blocks planted. Between the blocks are roads 24 feet wide. The trees are planted 400 to the acre, and admitting some failures, each block should contain 10,000 trees. On account of the lay of the land the planted blocks are in two tracts, one about twice the size of the other. All roads going lengthwise in the tract are called avenues and all cross roads streets. The longest avenue is nearly six miles through the planted rubber forest.

The soil is an alluvial deposit of dark colour, of uniform grain size, without any interrupting strata of different physical texture. In the places where borings have been made to ascertain the depth of the soil it has varied from 18 to 22 feet. Because of the physical character of the soil the rise of water from below by capillarity is continuous and even in the dry season, which lasts six months, the trees do not suffer from lack of water. The root system of *Castilla* on this soil is superficial. In other districts, where the soil is stratified, I have found that the roots penetrate much deeper in order to reach the water-supply. Laboratory experiments have shown me that roots of *Castilla* seedlings in 42 days have grown to a length of 3 feet 4 inches in order to reach a water-supply, which by mechanical arrangement was gradually distanced from the roots in proportion to their growth. In the same time roots of *Castilla* seedlings in the undisturbed soil on Zacualpa did not reach a greater length than 8 inches. A few years ago the land was covered with a layer of ashes through the eruption of a neighbouring volcano, Santa Maria, just across the Guatemala line. These ashes have formed a cover over the ground which materially assists in checking evaporation. The fertility of the soil is not unusually high, so that we may in time have to apply fertilizers. Experiments are now being conducted to ascertain the results of manuring this soil for rubber. The soil is rather poor in nitrogen and it has been found that the growing of leguminous plants between the rubber trees markedly influences the development of these.

If I add that the plantation is comparatively little exposed to high winds I have shown some of the reasons why I consider the natural conditions of this place nearly ideal for *Castilla* planting.

The method of planting first employed was to sow the seeds in nurseries, and when the seedlings were 4 to 6 months old they were transplanted. Very often, however, transplanting was not done before a year after sowing. The plants were then from five to twelve feet high. The seedlings were cut 5 or 6 inches below the surface, and topped, leaving a pole some 3 feet long. Tied into bundles, which were packed on mule back, these poles were carried to the field. With a pointed stake, holes were made in the ground about one foot deep, the pole placed in the hole and the soil pressed close to the stem. When this planting was done carefully and if rain fell within the next two or three days not more than 3 or 4 per cent. of failures occurred. In places where the soil was somewhat sandy the failures were more frequent. On Zacualpa as many as 18,000 trees have been planted per day in this manner. At first it was believed that shade was necessary, but it was soon noticed that this idea was erroneous and a system of planting in semi-shade was adopted. When clearing a certain amount of high forest trees were left standing, about four to the acre. It is now demonstrated, however, that even this amount of shade is too much on Zacualpa. On the other plantations, however, Juilapa and Zacualpa II, this semi-shade is beneficial as it assists the young plants through the dry season. These plantations are situated at a somewhat higher elevation, and the land is undulating and more drained.

Later experience has proved that the cheapest and surest method is to plant the seeds at stake. Nearly a year's growth is thus gained, and it does away with the expensive replanting where failures occur under the transplanting method. The seeds are planted in small hills, about seven seeds in each hill, three inches between the seeds. The hills are at a distance of about seven feet, in rows twelve feet apart. This method of planting appears at first sight decidedly wrong as the plants stand too close. A planter of Para rubber naturally thinks of the price of every seed be puts in the ground, but this is a minor consideration in the case of the small and rather cheap *Castilla* seeds. On Zacualpa we have the seeds for the picking, and any quantity of them.

In planting in the manner described we allow for a high percentage of failures in germination, we are prepared to give ants, lizards and field rats their due amount, and we still have plants in abundance. This is no theory but has been practised for several years with success. There are no complete failures in any hill, except where planting has been done in ground which is too sour. In such places we may have too replant in small patches after proper draining has been prepared for, and in such cases we use excess plants growing in the neighbourhood. During the first few months seedlings backward, misshaped, or where crowding is observed, are cut out at the time of each weeding. Generally we cut at least 50 per cent. of all the seedlings during the first six months. Detailed rules have been worked out for this first thinning and they will be applied in the field by the assistants in charge. Great care is exercised in the selection of the plants allowed to remain, and many points have to be attended to. Thus if a plant branches in a way that does not promise regularity, or if it has grown twisted or bent it is cut out. In selection those plants that show a tapering shape with thick stem are preferred to plants growing mainly in height, and plants with large dark green leaves are preferred to those with small leaves of a lighter or yellowish colour.

Advantage of Close Planting.

One of the great advantages of this system of close planting and successive thinning is the opportunity for selection, a matter which is generally overlooked, but which, no doubt, will be found to be a most profitable policy. In *Castilla* cultivation we often get trees which produce very little or sometimes no rubber. It is evident that such trees are an unnecessary expense on the plantation. Why should we waste time on valueless trees? Can this in any way be avoided? With our present limited knowledge of the nature of the tree we cannot say with absolute certainty whether a seedling will become a good "milker" or not. But in the course of my physiological investigations of *Castilla*, I have already been able to draw some conclusions, which give us certain indications on which we can judge in this matter. That is to say, we can in some instances say definitely that a seedling, which shows certain characters, will never produce a large amount of latex. On the other hand, we cannot guarantee that a number of non-producing trees would not be passed during the selection time. But we have found a way to reduce their number, and I hope that further investigation will considerably improve the method. There is, however, another important point which can be applied in this process of selection. It is the choice of rapid growing, healthy plants of a certain desirable type. It is of the greatest value to the planter to have trees which are as rapid growing as possible. Now with the transplanting system a certain amount of selection can be done, but this is before the transplanting process, during which the plant is always more or less injured. There is no selection possible after the transplanting. With the "at stake" planting system mentioned we do our most important selection after sowing the seeds. I will presently refer to the selection which precedes the planting.

With the growth of the young rubber trees, successive thinnings become necessary to prevent crowding. It is here the men in charge of the plantation have to exercise their best judgment.

We fully realize the necessity of plenty of air and light for the growing tree. If this is neglected the whole system naturally is detrimental. But there is no reason why such an important matter should be overlooked. We have presupposed that we have to do with intelligent planters and superintendents, who realize that rubber growing on scientific and profitable commercial lines is a shade different from potato growing, as our forefathers practised this necessary and honourable industry a century ago.

On La Zacualpa we thin the rubber stand several times every year until the third year, when we have approximately 800 trees to the acre. During the fifth year we tap fifty per cent. of these trees, selecting the poorest and leaving the best trees untouched. We tap heavily, that is, extracting as much latex as is possible. A few weeks later the trees are inspected. Those that have suffered from the tapping are marked and doomed. If they still yield latex they are cut up with numerous incisions, and a few days afterwards the scrap is collected and the trees felled. Those trees that promise to recuperate are left untouched for four months, when they are again tapped in the regular way. After a second inspection they are killed. Exceptional trees which do not crowd upon the permanent trees may be left to the following, or sixth year, when they are tapped with an ultimate view to their destruction. At the end of the sixth year we have 400 trees to the acre.

Many objections have been raised against this method of close planting and successive thinnings. The main point in question seems to be whether the cutting out of a number of trees, leaving stumps with the roots in the ground, would not be preparing breeding places for fungous or in~~forest~~ diseases. I admit that there is some truth in this objection. In talking about rubber planting I am fully aware of the many dangers that may and most likely will arise from pests, animal or vegetable, in our *Castilla* or other rubber plantations. But in endeavouring to find preventives we must first of all be practical. Methods that are impossible to realize in practice are not worth mentioning.

If we are afraid of leaving the roots of rubber trees in the ground, why do we leave the roots and stumps of the jungle trees when we clear the virgin land for rubber planting? There are hard woods which do not decay for a long time, and during the first few years there is a constant decomposition going on, in the ground and above it, of roots, stumps, branches, and even trunks. Examination will disclose the fact that all of these are affected by some fungus or another, and overground parts also by insects. Do these present any danger to the planted trees? They certainly do, but as long as the planted trees are sound, they are not likely to be attacked, and there is hardly any other way of preventing disease than by keeping the trees in good condition. One of the main factors affecting the health of rubber trees is the drainage of the soil. Keep the ground well drained, and the trees will be sound.

It has been suggested that the ground should be stumped before planting, and others have advised digging up the roots after the rubber trees have been cut down. This is all very good, but if we have to stump the ground in preparing our land, I think we had better give up rubber planting. At least as far as *Castilla* is concerned. To stump or dig up roots in an established stand of rubber is also a method not to be recommended, except in rare instances when absolute necessity arises, such as trenching for isolation of a tree affected by root fungus. The roots of the trees interlace, and any injury to these roots from wounding or bruising them is much more likely to permit an attack by fungus mycelia than leaving them undisturbed. In any case, the price of stumping would be prohibitive in Mexico and Central America.

It has been assumed that the tapping "to death" of alternate trees would be dangerous to the health of the stand. Why is tapping of alternate trees more dangerous than tapping every tree? As soon as all the rubber is extracted, that is in about a week's time, the trees are felled. In that time there has been no opportunity for any ravages of pests. There is a danger from intermediate or catch crops, such as cacao or coffee, and still they are recommended. How about the jungle belts that should be left at intervals in a rubber plantation? Do not these constitute a danger? Might they not become a breeding ground for pests? Of course, but we cannot eliminate all sources of danger, without making planting impossible.

There are essentially two ways in which we can start a rubber plantation. One is to treat it as an orchard. In this case we are restricted to a small area and we can naturally take better care of our plants, and probably obtain better results from our individual trees, but it costs more. The other method is planting rubber over large areas as we plant forests of other trees. Such plantations cannot receive the detailed care we can give an orchard, but it costs less in proportion to maintain. It is here we have to apply the methods of modern silviculture, and we must apply them in a scientific and at the same time practical and economic manner. As for the ultimate financial results they will be almost identical in either case, although as an investment the smaller place naturally presents a lesser element of risk.

Selection of Seeds.

We have noticed a decided increase in the rapidity of growth for every year since selection of seeds has been practised on La Zacualpa. This naturally stands to reason. Still the necessity for careful selection of seed for a rubber plantation does not seem to have been accorded the attention it requires. A farmer now-a-days is very particular about his seed corn, and a fruit grower thinks twice before he decides about the kind of tree he plants. Suppose a corn farmer sows seed that is very uneven in size, some fresh in the milky or green stage, others old and eaten by weevils. What kind of a crop will he get? When we want a hardy stock of fruit trees we take care to select only the best seeds. But a rubber planter seems to think that any seed is good, any tree is suitable as long as it is a *Castilla*. It must, however, be borne in mind that the whole life of the tree, its healthiness, size, strength, its amount of rubber, all depends upon the start it has. Unlike so many other agricultural industries, rubber culture cannot be immediately benefited by a lesson learned through bitter experience, because a tree, once planted, will last for many years and has to flourish or fail according to its fitness. Mistakes cannot be corrected as easily as in corn growing, or cultivation of similar crops. It is clear that it will pay a planter to exercise care in the first instance, even more care than in the case of many other plants. This does not imply that a bad start is absolutely hopeless, but rather that care and discretion in the beginning will pay in the long run, and will save the planter many disappointments.

It is naturally difficult, well nigh impossible, to make any detailed selection of seeds, when a large planting, say of thousands of acres, is to be done in one season. But the planter can always subject his seeds to the ordinary methods of selection, such as mentioned below.

When commencing a plantation always get the seeds from planters who to your knowledge cultivate their trees and keep them clean. Naturally a tree that is well cared for will supply better seed than a neglected tree. Choose seeds from trees that look healthy, have straight tapering trunk, a full conical crown, and are known to give a large amount of latex and rubber.

Seeds from young trees, four to six years old, are larger and look better than those obtained from older trees. It is proved by experiments and experience that seeds from such young trees develop into a healthier plant than seeds from older trees. Whenever the tree is looking yellow or sickly, carefully avoid its seed. The large seeds are always better than the small ones. In regard to size the seeds should be selected by using a screen with meshes one-fourth inch in diameter. All seeds passing through should be discarded. The next step in selection of seed is to place them in a vessel of water, and separate all seeds that float, or do not sink rapidly, as these are defective.

Influence of Maturity of Seed.

If seeds are taken from fruits which are not mature and do not have the clear colour of the flesh they will most likely either fail to germinate, or produce inferior seedlings. Experience has shown in regard to most cultivated plants that the maturity of the seed has a considerable influence on the offspring. Immature seeds lessen the vitality of the subsequent seedling and tree.

I have noticed that seeds from young plants are fuller and more rounded than those from older trees. The seedling from such a seed has smoother and bigger leaves than those developing from seeds with a loose seed coat and ribs on its surface.

The root development is much stronger in a seedling from seed taken from younger trees, and this is another reason why careful attention should be paid to the age of the parent tree.

There can be no doubt but that planters who are careless and do not select their seed, make a grave error which they will find out to their regret. Thousands of dollars have been wasted by ignorance or neglect in this respect. If a mistake is made in selecting or non-selecting of seeds it will not be realised before the lapse of at least a number of years, when it probably will be impossible to correct the blunder, and make the plantation as productive as it otherwise would have been.

Methods of Selection.

The process of selection should commence, as I have pointed out above, with the seeds. Whatever method of planting is adopted the most important time for selection is when the seedling has appeared and grown to a size which permits the distinguishing of its main features. In order to be able to exercise necessary judgment in this selection the planter should be thoroughly acquainted with the development of the plant in its various stages.

I have previously stated that a great variation exists between individual plants. This variability is evidenced in a large proportion of the trees producing a small quantity only and often an inferior quality of latex. Such a lack of uniformity necessitates a subsequent sorting and grading of the latex if a good result is to be obtained. If latex from all kinds of trees is indiscriminately mixed together the result will be a lowering of the standard. From a planter's view-point uniformity of stand is desired, and to attain such a result systematic seedling selection is a necessity.

It has been demonstrated by recent experiments that it is possible to secure by selection a great improvement in the uniformity of the rubber stand. It is equally possible to obtain a considerable increase in yield, and the planter should give the closest attention to these and other points which can be controlled by careful selection. The planter should first decide upon the type of tree he desires and when he has formed a clear conception of this in his mind he should go through the rubber forest, carefully observing the trees and selecting the number of trees he needs for the production of his seeds. When these seeds have been collected and treated in the best possible way, they should be further selected by the screen and the common specific gravity methods. When such seeds have germinated the resulting seedlings will clearly demonstrate the benefit of seed selection. As soon as the young plants have reached a height of 7 to 8 inches it is time for the planter to pass through his fields, eliminating all plants that are defective, backward, or in any other way undesirable.

Increased Size and Productiveness.

Only a superficial observation is necessary to show the planter that when a rubber tree is cultivated properly it re-acts to good treatment. If the trees have good soil with sufficient moisture, plenty of light and air, and no crowding or competition with other plants of its own or any other kind, it will grow quicker, remain healthier and more robust, and what is most important, it will furnish a greater surface for tapping, than if exposed to the vicissitudes of the natural struggle for life in the forest or in a plantation where the trees stand too close.

If we subject the trees to the best possible treatment according to modern and improved methods of silviculture we will soon be repaid for the additional care bestowed upon the plants. There can be no doubt but that the size of the trunk can be considerably increased by breeding and selection. There can be as little uncertainty in regard to the possibility of increasing the amount of latex in the tree. These improvements take, however, some time, and the rubber planter of to-day cannot immediately benefit by the gradual advances made in this connection. To him it is more important to take advantage of methods of selection which can be put into practice on his plantation already started. On such a place it is of the greatest consequence that all unproductive, sickly, or otherwise unsatisfactory trees be destroyed. It does not pay to cultivate trees which do not give a payable quantity of latex, and it is a waste of land to keep the ground occupied by such trees, which should be immediately replaced.

In regard to the rapidity of growth and the size of the seedling and the subsequent tree, it has long been conclusively proved that the heavier seeds are far superior to the light ones. Experiments conducted with a view of determining whether the size of the seeds have any effect on the vigour of the plant, have shown that plants grown from the heaviest seeds attain a greater size even if they do not always germinate as rapidly as the smaller. It has further been demonstrated that plants grown from the heaviest seeds have a greater power of resistance to drought.

To insure a good stand and a greater yield, none but the largest and heaviest seeds should be selected, and of the seedlings the most rapid grower, with the healthiest and most vigourous appearance.

Experiments in Improving Castilla.

So far, very few experiments have been made for the purpose of improving the *Castilla* rubber tree, or in order to ascertain the growth of the seedling under different circumstances. A series of such experiments were started in April and May of 1906, at La Zacualpa Botanical Station in Mexico. The results of these initial experiments are not yet available for publication, but I have found that so far a marked improvement is noticeable in seedlings placed under favourable conditions and subjected to rational and systematic treatment.

Habits of Castilla.

When we study the *Castilla* in its native conditions, in the natural surroundings in which the tree has been able to exist and flourish in competition with other trees, we learn many a useful lesson as to its requirements under cultivation. It is by no means essential that a cultivated plant should always have to be grown under conditions identical to those of its original habitat, but we can always derive pointers from a close observation of nature.

One of the first things we notice when observing *Castilla* in the wild state is that it prefers small openings in the forest and that it never selects very heavy shade. In this regard, it is similar to its relative the Guarumbo tree which is always found in localities where the primeval forest has been cleared at some time or another. The Guarumbo, or trumpet tree (*Cecropia*), is very common through Southern Mexico and Central America. It is often called the false rubber tree, because to the unitiated newcomer it resembles at a distance *Castilla*. As soon as a clearing is made *Cecropia* will gain a foothold and as it is of very rapid growth, it soon grows into a small tree. I have noticed on some plantations that the managers studiously avoid cutting down the Guarumbo trees wherever they grow among the rubber. I was informed that this was done on purpose as the Guarumbo tree resembled the rubber tree so much that it helped to carry out the impression of an even and good stand of rubber trees. Inspecting shareholders did not notice the difference. I am ready to believe this, as there appears no other reason why the Guarumbo tree should be left standing. It is not good as a shade tree and as it consumes a great amount of water and plant food, it is decidedly detrimental in a rubber stand.

In the natural succession of the forest trees both *Cecropia* and *Castilla* are secondary elements. The seed of *Castilla* is so thin shelled and perishable that it needs a moist place in which to germinate as it would otherwise be destroyed by the heat of the sun. We therefore always find the young seedlings growing close to other trees which give them sufficient protection.

Castilla depends in many other respects upon its neighbours for safety. It is a very brittle tree, easily broken by the wind and therefore needs a wind-break. We always find *Castillas* in the pole stage standing close to other trees, which indicates that they have been able to survive only by reason of the protection afforded by the other trees. It may be inferred that if this is true we would never find a *Castilla* standing separated from any neighbours. I think that in every case where an old *Castilla* tree is found single it has either been planted by man and protected, or, if a wild tree the surrounding trees have been destroyed in some way or another. It is at least on very rare occasions that *Castilla* is able to live through the sapling and pole stages without protection against wind.

Another way in which *Castilla* gets protection from neighbouring trees is that these give shelter to the ground, retain moisture, and prevent the soil from cracking. Castilla is very sensitive to these influences, as its roots do not develop properly in hard-baked ground.

Castilla does not, on the other hand, develop well in shade. It grows very slender, with a weak trunk and an undeveloped crown. The tree needs plenty of light for its foliage and it is only where the *Castilla* tree has room enough to spread its branches and expose its foliage to the rays of the sun that it can successfully maintain its position in the struggle for space and light.

In districts were a distinct dry season prevails, *Castilla* is pronouncedly deciduous and drops its leaves at that period of the year, while in a humid region the shedding of leaves goes on all the year round. On the Pacific side of Sierra Madre in Mexico, the dry season lasts from January to May, and the rubber tree begins to shed its leaves with the advent of this season, and towards its close the trees are almost destitute of foliage.

It is generally stated that *Castilla* does not flower and set fruit before it has reached an age of about five years. Another statement is that flowering commences when the tree begins to develop permanent branches. My observations show that if *Castilla* is grown on good soil in a suitable climate, and if the development has been normal, the tree will flower in its third year, whether it has permanent branches or not. I have seen many two years old trees with flowers and fruit, but I would consider this premature, and indicating that something is wrong with the tree.

The season of flowering is from February to the beginning of May in the Zacualpa district in Mexico, and in Western Guatemala. The earliest fruits begin to ripen in May and ripe seeds can be had until August.

The flowers are unisexual, but both sexes occur on the same tree. I have often heard it stated by planters and others, that there are two distinct trees, the male and female. It is also said, and generally believed, that the "male trees" do not produce latex as well as the "female." In my experience all the older trees carry both male or staminate and female or pistillate flowers. While the trees are young they often have only staminate flowers but after reaching a more mature age both sexes are present. I think we can safely abandon the idea that some trees are male and therefore no "milkers," while others are female and good milk producers. Such an analogy is rather far fetched and has a strong flavour of ignorance.

I have found trees on which the female flowers have been sterile on account of insufficient development of the ovary. Such trees naturally do not produce fruit. Whether there are any permanently sterile trees is a question yet to be investigated. I have seen numerous instances where a tree had no flowers one year but developed a profusion of both staminate and pistillate flowers the next year. I have also noticed cases where a tree had an abundance of fruit one year and none the following. Whether there is any regularity in this development of flowers and fruits I am not in a position to say at present.

The idea that a sterile tree, or at least a tree not carrying fruit, produces less latex than a fruiting one is erroneous. I have noticed instances of trees with plenty of fruit giving little or no latex, and again of non-fruiting trees with an abundance of latex. It seems though as if a tree generally yielded more latex while in fruit than during any other time of the year.

The staminate flowers consist of imbricated scaly flat pods, which open along the edge like a clam shell, with clusters of yellowish stamens on the inner side. These pods or heads are up to one inch long, as a rule, but another kind of smaller staminate flowers are found immediately below a cluster of pistillate flowers. The stamens in these semi-spherical heads often have pollen grains which are shrivelled up and apparently sterile.

The female flowers have numerous ovaries on a common disc-like receptacle or cup, covered with scales larger than those of the staminate flowers. Each pistil carries two straight, scarred, two-parted styles.

The fruit is first green, and when ripening gradually turns a deep red, finally fading into an orange colour. From eight to thirty fruits mature in each cluster, and a much larger number never develop but remain in the form of larger or smaller scales. At the apex of every fruit is a small hollow in which the dried up remnants of the style can be seen.

The Best Type of a Castilla Tree.

We have yet to ascertain the cause of the difference in yield of individual trees, or at least, we must find out what trees are the best producers and the most rapid growers, before we can enter upon the problem of determining or developing the best type for a rubber tree. On general principles we should require a tall, straight trunk, with a dense crown at the top of the tree. But the natives hold that a tree which is not too tall and which has a tapering trunk, gives a larger yield and better rubber than a taller tree of the same age and with the same girth at the base. I have been able to verify this by actual experience, but I cannot give any explanation of this fact.

The object is to develop a trunk with as large an area as possible for tapping. Branches seldom attain a tapable size and a rubber stand with clean stems, without intertwining branches or underbrush, is easier to work in than in a tangled mass of trees growing without order and care.

We have many instances of large trees with tapable branches, or trees which have branched from the base, being regularly tapped and producing a quantity of latex. It may seem an advantage to have several stems to tap instead of only one, where a single shoot or a single trunk has developed, but there can be no question as to the fact that where several branches are allowed to develop the growth of the main trunk is greatly retarded.

It is therefore necessary to have a tree straight and clean boled, in a condition to make the best of the period of maximum growth, the time of which has not yet been ascertained. We know for a fact that the best rubber producer has a thick, compact crown. The conical form of crown is also to be recommended as it naturally receives more light than a flat crown. After the *Castilla* growing in the wild state has obtained its maximum height the crown always becomes flat and rather ovate in shape, while in youth, when the tree is growing vigorously under normal conditions, it has a sharply conical crown. Every kind of tree has a maximum height to which it is able to pump water, and when this height has been reached the growth of the tree ceases because the crown cannot be supplied with sufficient water. The normal rubber tree should not, therefore, be very tall as in the best situations the wild tree reaches a height of about sixty feet, and the over-mature trees always have a very spreading crown. Sometimes dry topped young trees are observed. This is due to unsuitable conditions in some respect or another, and we recognize this as a disease, called by foresters the "staghorn disease."

The leaves should be large, with a fresh green colour, the bark thin and smooth. Some trees have leaves with stiff, bristly hairs, and I have found on some plantations almost every tree covered with these stiff hairs, sometimes resembling prickles. In cases where such hairs occur the trees were below the average in regard to yielding capacity. It seems therefore obvious that hairs should be absent in the future type of rubber trees. There is also another reason for this. We know that the hairs are one mode of protecting the leaves against excessive transpiration. The latex is another means by which the tree prevents its water supply from evaporating too rapidly through the leaves. If we develop a tree without hairs we should be able to force the tree into preparing more latex in order to keep up the equilibrium, not allowing too much water to transpire.

Remarks on Function of Latex.

By the above I do not mean to say or indicate that I consider the function of latex as solely one of water storage or prevention of too rapid evaporation. But field observations as well as laboratory and breeding experiments have conclusively shown that the protection of the plant against too rapid transpiration is one of the functions of latex, at least in *Castilla*.

I could give a number of proofs for this, but as the question is more fully discussed in my Handbook on *Castilla*, above referred to, I will here mention only one instance, which first fell under my observation in July 1905. In walking through a stand of four year old rubber trees, one early morning, I stopped and measured some two dozen trees, which were especially well developed. I noted down in my field-book certain characteristics of these trees, and with my thermometers, took the soil and atmospheric temperatures, near one of the trees standing about in the middle of the group of trees measured. I intended to return two hours later, when the full heat of the sun had been acting on the trees to re-measure the trunks in order to find out the shrinkage of the trunks at different times of the day. I was delayed, and returned some four hours later instead, at 10-47 a.m. The first thing I noticed was that one of the trees which in no way differed from its neighbours upon my first visit, was now looking very exhausted, with drooping branches and leaves hanging limply downwards. Another tree standing by looked perfectly fresh, while some of the others showed signs of having been slightly affected by the now scorching rays of the sun. This difference in power of withstanding sudden high temperature was so marked that I decided to try the different trees for latex. The result of a small cut in each tree was that *A*, the tree with drooping leaves, had no latex, while *H*, the most fresh looking tree of the lot, had plenty. Between these *B*, *C*, etc., showed a gradual increase in the amount of latex with the exception of two trees *F* and *G*, of which the latter had less latex than the former, but it was much thicker. This year I noticed the same difference at the end of January. Closer observation now revealed the fact that *A* had much more hairs on the leaves, petioles, and branchlets than *H*, and thus ought to have been better protected against too rapid transpiration. Counting the stomata on the leaves, I found that the number was smaller in *A*,—another protective device. The barkpores were almost equal. Five weeks later *A* commenced to drop its leaves, and was almost bare at the end of March, when *H* still had all its foliage left. *A* did not commence to drop leaves before the last week of April, and did not loose many before the rainy season set in, and new leaves were again developed. *A* recovered rapidly in June, after the rains began, and was soon clothed in full foliage. In January, *A* had a small amount of latex, and whenever cut during the dry season a few drops appeared in the wound. After a few weeks of rain no latex appeared from an incision, i.e., the tree behaved exactly as it had done in the rainy season of the previous year. *H* had an abundant supply of latex in the wet season, and in the dry part of the year this latex was still present, but was less watery, or more concentrated.

How are we to explain this fact that a tree, such as *H* in the above experiments, with less of ordinary protective devices, but more latex was better able to stand excessive transpiration than *A*, with rather well-developed protective arrangements, but only little or no latex? I think the only answer is to be looked for in the presence or absence of latex in respective trees. Both were vigourously growing trees, and *A* did not seem to be much handicapped by the absence of latex, except in regard to transpiration. When having the advantage of a humid atmosphere and plenty of water after the beginning of the rains, the tree grew as well, and almost better than the others. It is also worth noticing that in the dry season a small amount of latex appeared. It was all the tree was able to produce for its protection against rapid transpiration, and by means of this and an early leaf-fall it could survive the vicissitudes of the drought.

I will also briefly relate one of my laboratory experiments, which has a bearing on this matter. Two *Castilla* seedlings were grown in pots, and when they were four inches high one was placed under a double glass bell, the outer room of this filled with an orange-coloured liquid to give the desired light, and the inner bell constantly filled with well saturated air. The other seedling was placed in a bottomless glass cylinder, and by means of a fan, kept going by a clock movement, a constant exchange of air was secured in the cylinder. This was further placed so that it was exposed to the sun all day long. The roots received all the water they could absorb, and thus the transpiration was kept at a maximum. First the latter plant was very weak, but gradually recovered strength. After three weeks both plants were examined, both micro- and macroscopically as to latex. The plant in the moist air had well developed latex vessels, but the liquid in these was thin, and without any formation of globules. The plant which had been exposed to excessive transpiration had the ordinary latex of young seedlings, but rather concentrated. To make sure that this result was not merely caused by an individual or inherent character of the seedlings employed, I renewed the experiment, taking care to select seedlings which did not appreciably differ in any respect. The result was again the same.

I consider that this shows that when *Castilla* is grown under certain conditions the quantity of latex produced in the tree is reduced to a minimum, while under conditions favourable to or assisting excessive transpiration *Castilla* will produce latex ***as a means of protection.***

How are we to explain the fact that *Castilla* in some places in the mountains of Southern Mexico, where the rainfall is high and the atmosphere laden with moisture, does not produce latex, or at least a very small quantity? I take it to signify that in those places the transpiration is less than on the plains. This is, of course, only assumption, and the question is still open.

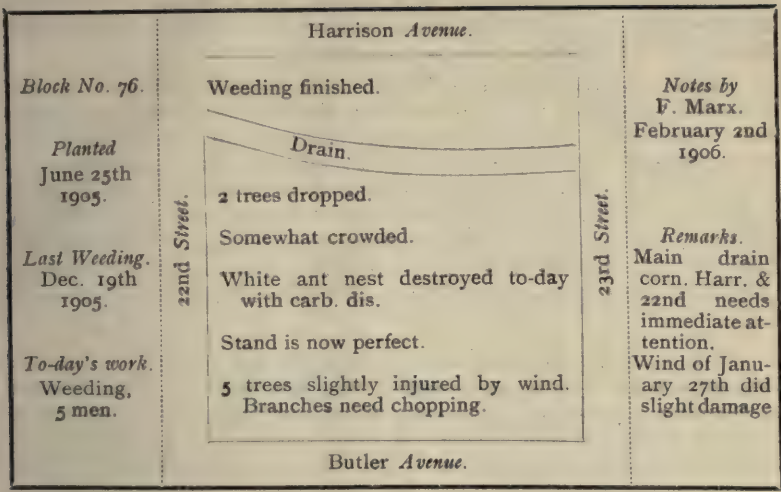
It has been claimed by certain theorists that the sole or at least the principal function of latex is protection against the natural enemies of the plants. How is it then that those individual trees of the same species, which do not produce latex, are not instantly devoured by insects and other pests? Let those who know answer this. I think that the conclusion of latex being solely a protection against insects or other animals is as narrow as the theory that spines are developed on certain plants for the same purpose, solely for the protection against animals. No plant physiologist or ecologist who has studied the question in nature would now-a-days maintain this. I do not deny that latex in the rubber trees may *incidentally* be a means of protection also against insects, but this certainly is not its main function.

Tapping Operations on La Zacualpa.

There has been a great difference of opinions as to the age at which a *Castilla* tree can be tapped. We have, however, to go more by size than by age. In one district the average tree may reach a tapable size when 6 years old, in other places not before 10 years of age. A definite rule can therefore hardly be laid down. The term of 6 years was tentatively put forth by most planters in the early days of planting, that is 5 to 10 years ago. Now I would say that the gathering of rubber from trees less than 8 years old is not likely to be advantageous. On Zacualpa we tap in the 7th year all trees with a girth of 28 inches at three feet from the base. Such a tree takes four incisions, nine inches long. In the 8th year we expect to tap all trees down to 25 inches, and this minimum girth for a tapable tree will then be maintained. After the 8th year the greater number are probably ready for tapping. One incision drains a larger area on the stem than in *Hevea*.

It is well known that rubber from three to four year old trees is decidedly inferior. Consequently we cannot go by size alone when we speak of young trees. The size has, however, more to do with the productiveness than the age. But we must take the "maturity" of the latex into consideration.

In order to keep track of all work performed on the plantation a series of observations are to be made by the assistants, and the data thus obtained will serve as a guide in laying out our tapping plans. As I have already mentioned the plantation on La Zacualpa is laid out in square blocks. All records in connection with each separate block are filed on cards, such as are now common in most American business houses. The blanks are printed ready and the cards appear something like the following figure, when completed with notes:—



Each assistant will be supplied with a note-book, the pages of which are ruled in the above manner, and he is expected to make field-notes of any observations made during work or while riding over the estate. The notes are written on the card in a position indicating the place in the block, so that the men in the office are able to direct a foreman to attend to any small matter needing adjustment. From these cards maps can be drawn showing the exact condition of the plantation at any special time.

These notes are handed to the superintendent at the end of the day's work and then copied on permanent cards which are filed in drawers in special cabinets. In this manner a large amount of detail is always ready for reference, and the history of any particular block can be learnt in a few minutes time. With this system we will not be much handicapped through changes in the staff, as a new assistant with ordinary intelligence can grasp the details of the plantation in a few days. Similar notes are to be kept of tapping and all other operations in the field.

We have fully realized the necessity of training our tappers, and we expect an ordinary tapper to cut 1,000 incisions per day, that is to say, tap 250 trees with four incisions, up to one foot long. Tapping should be done between 5 and 11 a.m. Evening tappings will not be practised as the distances are too great, and it would not pay to have the men walk several miles to tap probably one hour in the evening. Moreover, in our rainy season it almost invariably rains in the afternoon, and tapping must cease during a heavy rain to prevent loss of latex from washing.

The problem that faces us within a few years on La Zacualpa is to tap over two million rubber trees. We know that we have to tap these twice in the six months season available. A simple mathematical calculation shows the amount of labour necessary, as well as the great importance of our developing as economic and labour saving methods as possible. Fortunately rubber is a crop which will stand more expensive labour than almost any other tropical product, even if we had a drop of over 50 per cent. in the present market prices.

In tapping a *Castilla* tree all the latex exudes from the wound in a time varying from 20 minutes to two hours. After that time very little latex appears. Two days after tapping all wounds are inspected and cleaned of scrap. If an incision has been too deep, penetrating into the wood, the wound is disinfected by the scrap collector, who for that purpose carries a brush and a can with a mixture, the application of which prevents fungi from getting a foothold. A normal wound, where the wood is still covered by cambium, heals quickly and is not, as a rule, attacked by borers or fungi.

The amount of latex obtained from a single tapping is so large that on old trees quite good-sized cups are needed. The system of pushing the edge of the cup under the bark is not suitable on *Castilla*, as latex will run to waste from the wound made, and the hold of the bark on the rather large cups is not sufficient. They sometimes drop, and this must be prevented. Driving nails into the trunk results in bad cankerous wounds, and with the system of tapping employed the number of nails on each trunk would soon be considerable. The cup is made with one side slightly curved inwards to suit the trunk approximately, and from one side of the edge of the cup a string is led round the trunk, and with a hook fastened to the other side of the cup. The placing of a cup on the trunk is done with less manipulation than is needed to press the edge under the bark or driving in a nail and hanging a cup on this.

The latex is emptied from the cups into small galvanized cans holding 2½ gallons each. These are carried to the nearest collecting depôt, never more than 600 yards away, where the latex is weighed and collected into big cans, somewhat like the large milk cans used in dairies. From here the latex cans are transported on wagons to the rubber factory. All cans and cups are rinsed with clean water at the depôts, and at the end of the day's work placed in a small shed, erected at each depôt. Here are kept all the tools needed, in order to save the transportation back and forth every day to head-quarters. As the latex from young trees is very apt to coagulate before reaching the factory, a small amount of formaldehyde is added to each can by the foreman in charge of the depôt, where collection has been made. One depôt is the central station for each series of four blocks, and thus the depôts are placed at every second crossing along alternate avenues. Communication between the depôts is made easy and one assistant is able to supervise the work at a larger number of depôts, than if they were scattered about the plantation. In the office every depôt is known by a number, marked on the map, and during tapping control can easily be kept of the returns from each depôt.

The rubber plantation will further be divided into four fire districts, each with a patrolling watchman, who by easily accessible field telephones can quickly report to head-quarters when necessary. The labourers are at present divided into two camps, one at the "finca" as the buildings of an estate are called in Mexico, the other some 3½ miles distant, in the middle of the rubber plantation. In the future an electric tram system will be laid out to facilitate transportation on the estate. The new Pan-American railroad passes within a few miles of the plantation buildings, and La Zacualpa station will mark the place of communication with the outer world.

The Preparation of Rubber.

At present the rubber factory is in temporary quarters under the roof of the estate saw-mill. A proper factory building will be erected next year. Briefly stated, the system of preparing rubber, which will then be adopted, is as follows :—The latex brought in from the field is emptied into a collecting tank, where an equal amount of water is added. Inside this tank is an endless screw which slowly revolves and thus mixes the latex and the water without causing a separation of the natural clumps of globules. In case the preparation has to be postponed, a small amount of dilute formalin is slowly added from an automatic drip can. From the collecting tank the latex passes through a strainer into a stirring vat, where more water is added and the mixture is well stirred; the temperature being slightly raised with steam passing through pipe coils inside the vat.

If we adopt a smoking or fumigating process, which is not yet definitely decided, the latex would next pass into a zinc cylinder and through a series of sieves between which the fumes are pressed. The thoroughly fumigated latex falls into a vessel, whence it is run off, fifteen minutes later, into settling tanks. Here the creaming of the latex takes place, and by very gentle stirring of the top layer of "cream" coagulation is assisted. Sometimes a coagulant has to be added, but more often the latex shows a tendency to coagulate too rapidly. From time to time some of the mother liquid, which is dark brown, resembling beer, is drawn off from below and clean water is slowly added.

The coagulated rubber slabs are passed on to the washing machine, and after a thorough washing, the rubber is dried *in vacuo.*

It is very difficult, even by adding coagulants, to effect the coagulation of all the rubber in the latex. As an adjunct to the creaming process all of the remaining latex, after two creamings, is passed through a centrifugal separator, and after this the mother liquid does not contain any more rubber.

All the rubber is pressed into blocks in a strong screw press after drying. Two years ago Mr. Harrison prepared with tartaric acid on La Zacualpa a big rubber block as an experiment, and it proved to be the most attractive and practical way in which we can ship the clean plantation *Castilla.* I have received the advice from English rubber brokers to send *Castilla* rubber as crepe, but I greatly doubt the advisability of this, as the oxidation would be considerable, and *Castilla* suffers more from this than Para rubber.

Sulphurizing the Latex.

The addition of finely pulverized sulphur by a process corresponding to the vulcanization suggested itself, in the early stages of my experiments with *Castilla* latex in the laboratory at La

Zacualpa. This sulphurizing the latex is, of course, easily feasible, but beyond its preserving action on the crude rubber there is very little to recommend it to the planter. From the manufacturer's point of view, however, a very strong objection will be raised, and it seems to me this cannot be overlooked. In whatever way we add solid sulphur to the latex, the quantity will vary on different plantations and no uniformity can be achieved. This method further lends itself to adulteration, which the rubber buyers always seem to be afraid of. It would in every case be necessary for the manufacturer to analyse his crude rubber for sulphur, and in most instances he would have to desulphurize the rubber before vulcanizing. As the rubber must be masticated before it is mixed with the various ingredients necessary in manufacturing different articles, there is nothing to be gained in the way of preserving the "nerve" of the rubber.

I mentioned above the disinfecting and preserving action sulphur would have on the crude rubber. My series of experiments on sulphurizing latex and preparing rubber from thus treated material consisted of 63 different experiments, each varying from the others in some more or less important respect. I made good samples of rubber, and bad ones, from the sulphurized latex. In most cases there was no development of bacteria in the rubber, even though the samples of rubber were exposed in the culture jars to an atmosphere full of spores of moulds and decaying latex was poured over the rubber. Inoculation of bacteria cultures made of different forms occurring in "tacky" rubber was tried, but failed to develop on samples where a thorough admixture of latex and sulphur has been accomplished. The preserving power of sulphur mixed into the latex seems undoubted.

I have tried many various methods of smoking the *Castilla* rubber, and of coagulating by means of smoke. The most successful one is, I believe, the following. The fumes of burning sulphur were pressed into the latex for varying periods, and it was found that this assisted considerably the coagulation. I then mixed fumes of burning sulphur with the smoke of creosoted wood, pressed this mixture through a cooling apparatus to slightly bring down the temperature, and thoroughly fumigated the latex. This coagulated quickly and gave a grayish rubber, perfectly transparent, with a high degree of tensile strength. It has not deteriorated in the six months that have passed since the experiment was made. Whether this method will be incorporated in the manufacturing process on La Zacualpa depends on further experiments. The present results indicate that there is a possibility in this direction.

Rubber Experiments.

Before ending this brief description of conditions on La Zacualpa, I wish to mention a few words about the experiments which are being conducted at La Zacualpa Botanical Station and Rubber Laboratory. This institution began its work on December 1st, 1905. Its purpose is the scientific investigation of the various problems connected with rubber culture. In the short time of its existence the station has not been able to accomplish very much besides laying the foundation to a systematized study of *Castilla* and *Manihot* rubbers. Considerable time was taken up in organizing the work, and in equipping and arranging the laboratories. These consist of a chemical laboratory, fully equipped with all necessary apparatus and re-agents for analytic and experimental work; a plant physiological laboratory supplied with ordinary instruments and microscopes; a bacteriological department with all the paraphernalia pertaining thereto, incubators, sterilizers, microtomes and microscopes; a rubber experiment department with various appliances; a shop for making models and repairing instruments; a library with reference books, literature on chemistry, tropical agriculture, entomology, botany, coffee, and rubber, about forty periodicals, and some 4,000 pamphlets on agricultural and related subjects.

Our first work was to take a survey of conditions on the rubber plantation. Detailed observations were made of the rubber over the entire estate. These data were copied on cards such as intimated above. Maps were made showing the condition of the rubber on different areas and from different points of view. Suggestions were made as to treatment of the rubber stand. A drainage system was partly worked out. 30,000 trees were measured to ascertain the average girth and height of trees of various ages. Observations on branching, leaf-formation, root-development and light requirements were made. A complete working plan for 30 years was formulated and submitted to the managing director. Insect and fungus diseases were studied and remedies tried. Means for preventing forest fires in the rubber were suggested.

A number of well-developed young rubber trees were selected in the field and transplanted to the experimental grounds, which had been opened. Here seeds of different *Castilla* varieties have been sown. Ceara and other rubber producing trees and vines have been planted. It is intended to get a complete collection of the world's rubber and gutta percha plants. *Castilla* seeds have been sown under varying conditions of soil to ascertain the difference in development. Manuring experiments have been commenced. Influence of catch crops is being studied. Observations are made as to the best method of weeding, and the result of this as shown in the progress of the rubber trees. Pruning and transplanting experiments are going on, as well as experiments in grafting and hybridizing.

In the course of the plant physiological work experiments on transpiration have been commenced; the temperature of the tree and of the latex in the tree is ascertained under different weather conditions; the effect of wounding is studied; root and bark pressure is experimented upon; relation of leaf-fall to latex is one subject of investigation; several other lines of inquiry have been entered upon, and numerous new problems will be studied in the future.

The bacteriology of latex and crude rubber is not entirely unknown, and we have ascertained some very interesting facts. Before these are published, however, the flora of the crude rubber is being classified by a specialist and the enzymes are carefully investigated. We have tried over one hundred different chemicals in regard to their disinfecting power, and we have no difficulty in preserving the latex for a considerable time. By the addition of formalin to the latex it can be kept for at least 27 months without changing its character. This is the oldest latex I have had to deal with, but I am inclined to believe that the latex can be kept indefinitely. I have deposited in La Zacualpa laboratory samples of latex, which are now 11 months old, and I put up a sample with formalin in June 1905, brought it to Stanford University in California, where I last saw it in September 1906, apparently in the same condition. The 27 months old sample above referred to was given me by a Mexican rubber planter, and I made from it a sample of rubber, which in no way differs from that coagulated from fresh latex. Salicylic acid in small quantities has proved to be a good disinfectant of the latex, but I do not know how it would effect vulcanization. Creosote coating and other methods of mixing creosote into the latex and rubber have been tried.

A suitable hydrometer for measuring the density of latex has been devised and is used with success.

Analyses of rubber soils have been made, and one series of analyses of special interest is that of the soil on Zacualpa down to a depth of 20 feet. Numerous analyses of latex of *Castilla* and *Manihot* have been made, as well as of crude rubbers. The chemical constituents, especially the resins, in latex from trees of different ages are being compared and studied.

Soil temperatures on the rubber plantation are taken at regular intervals and comparative studies made of these with the tree temperatures, and the ordinary meteorological observations taken daily as to temperature, wind, light, humidity, atmospheric pressure, evaporation, serve as a basis for all our studies of the ecology of *Castilla*.

One of the assistants made a four weeks' journey of inspection to the Isthmus and Trinidad River rubber districts in May, and the director of the station was dispatched, in September, on a voyage round the world in order to study conditions of rubber cultivation in various tropical countries as well as market conditions in Europe and America.

The station has been fortunate in having the confidence and unlimited support of the managing director of the company, Mr. O. H. Harrison, who is ready to listen to and accept all suggestions based on actual scientific observation and conforming to sound business principles. Many Mexican planters have recognized the work on Zacualpa, and among others the President of the Republic follows the station with the closest interest. We are often asked questions in regard to rubber culture, but as the institution is a private one, we have not been able to devote time to giving directions to outsiders. A series of bulletins will, however, be published, giving the most important results of our work. Three of these bulletins are in press, but will not appear in print, before the return of the director to Mexico.

Ceara Rubber in Mexico.

The only attempt to cultivate Ceara in Mexico was made a few years ago by Mr. O. H. Harrison on his Esmeralda coffee plantation, some 12 miles from La Zacualpa, at an elevation of 2,000 feet, on the slope of Sierra Madre.

Mr. Harrison had considerable experience of rubber in Brazil, and it struck him that Ceara rubber would be a suitable crop on the highlands of Chiapas. Seeds were procured from Brazil and planted on Esmeralda. The plants were left almost entirely to their own device receiving very little care beyond a few sporadic weedings. Compared to other Ceara trees I have seen they have not developed very well, but the amount of latex is satisfactory. Tapping experiments will be conducted regularly on these trees, a few hundred in number.

Guayule Rubber.

The invention of a practical method of extracting the rubber from the Guayule plant of Northern Mexico has lead to over-sanguine estimates of results from this new rubber industry. Factories are being erected in numerous places, and the periodic press reports the floating of one big company after another for the purpose of exploiting the Guayule covered plains of the north of Mexico, and of certain districts in the southern part of the United States.

In considering the development of the *Castilla* rubber industry of Central America it is necessary to pay some attention to the reports on the Guayule product, especially because it has been maintained by some promoters interested in the question that the Guayule would supersede the production of all the other rubbers, that the Guayule would lower the prices in the world's market to such an extent as to render cultivation of *Castilla* and *Hevea* an impossibility, and that the Guayule would supply the entire demand of the world for crude rubber. I shall here briefly discuss the question.

The much advertised Guayule rubber is obtained from *Parthenium argentatum* A. Gray, a shrubby plant belonging to the family *Compositae.* This plant occurs in the bush prairie formations of the northern part of the Mexican highlands, or more specifically, in the northern districts of the states of San Luis Potosi and Zacatecas, in Chihuahua, in the eastern part of Durango, and in the southern districts of Coahuila. In the United States the plant occurs in Texas, New Mexico and Arizona, in limited areas.

The supply of Guayule has been greatly over-estimated, principally because of the confusing of Guayule with another species of the same genus, *Parthenium incanum* H. B. K., which is far more abundant and grows all through the Guayule territory. This has been estimated to as much as 28,000 square miles, but it must be remembered that the patches of Guayule are far apart and one can travel over miles in the Guayule country without seeing a single specimen. The general estimates of Guayule on the acre is from

400 to 700 pounds, taking an average for large areas. This is undoubtedly too high an average. By actual count in very favourable localities I have become convinced that even under the best conditions not more than 1,500 pounds can be obtained per acre from the Guayule patches, and these constitute less than one-tenth of the total area of the territory, where the plant occurs. That my estimation in this regard is upheld by others who have investigated the matter and expressed an unbiased opinion is shown by the following lines, translated from an article by Dr. R. Endlich, in "Der Tropenpflanzer." The author says in part:—

"The supply of the Guayule is very unevenly distributed in the territory the plant occupies. In most places the plants are isolated, growing sometimes in large and often in small numbers among the other plants. At rare intervals small patches are found where it is predominating in the chaparral flora."

"It is very difficult to make an estimate of the average supply per hectare, both on account of the uneven distribution of the plant and because of the difference in size of individual specimens. In favourable territory I have on several occasions counted thirty to forty plants on an area of 100 square meters, which would mean a total supply of 3,000 to 4,000 Guayule plants per hectare (=1,215 per acre). The differences in size and weight are so great that in places where the plants are small and grow close together ten plants have a weight of only one kilogram (=2 1/5 lbs.), while in the best territories some of the trees weigh as much as 3 kilograms each. The average weight will probably not exceed 500 grams (1 1/10 lb.) per plant."

"Estimates of the Guayule supply in large areas vary from 500 to 800 kilograms per hectare, but the distance between the different places where the plants are found is often considerable, and must be taken into consideration."

The Guayule shrub is about two feet high, with knotted, spreading branches and sparse, greyish leaves. The whole plant contains rubber, with the exception of shoots bearing leaves and flowers. Consequently the whole plant is gathered and the supply is rapidly exhausted on the area, where gathering is done. Even the roots are in most cases pulled up by the collector, and the opportunity for re-growth is reduced to a minimum.

The rate of growth is very slow, so that a plant 20 inches high is three to four years old, while plants five years old are not more than 30 inches high. Such a plant would weigh about four pounds. In view of these facts it seems more than illusionary to speak of growing the Guayule plant for commercial purposes. Brought under domestication the plant could naturally be made to grow much faster, but there are still other factors to be taken into consideration. The dry country in which the Guayule plant grows, has a very scanty and irregular rainfall. For an agricultural crop that kind of land can hardly be expected to supply the necessary requirements, and the uncertainty about the germination of the seeds brings in such an element of chance, that indeed very much faith in Providence must be present to undertake the growing of Guayule without any provision for occasional artificial irrigation. The price paid has been as high as $43 per ton of dry plants, pressed into bales, and delivered at railroad station. With that price, and the slow growth of the plant it is difficult to see how anyone can in earnest consider the cultivation of Guayule. Factories operating a large area should naturally take some steps for re-covering the ground with Guayule, but beyond sowing the seeds, and taking the chance of their germinating, and growing in a few years to a size, that can be utilized, it is hardly possible to do anything.

As for the fear of Guayule filling the market to the exclusion of crude rubber from previous sources of wild tropical rubber and from present and future plantations, such an idea is hardly worth refuting. If we remember that the requirements at present of the United States alone amount to more than 60,000,000 lbs. annually, a simple mathematical calculation, based on the most exaggerated expectations of the output of Guayule rubber from the entire territory where it is growing, will show the rôle this product could have in the world's market, even supposing that the supply was inexhaustible and as large as claimed by Guayule enthusiasts.

It may be added that the quality of Guayule rubber is very inferior, the rubber being very sticky and rapidly deteriorating. The market value is very low in comparison with that of first class rubbers, but it still leaves a wide margin for profit, and the supply of rubber plants is apparently enough for a few factories, not too closely situated. As a special product the Guayule has a market of its own, and if cultivation of this plant can be accomplished on a profitable basis, it will prove a great boon to the sterile parts of Northern Mexico.

Another rubber plant of Mexico, *Euphorbia elastica* has been spoken of. I have seen the plant, but not been able to obtain a sample of the product, which I understand, however, somewhat resembles the Guayule rubber.

Postscript.

I may have failed to convey a right idea of the extent of our Mexican rubber industry in my discussion on the previous pages. But I hope I have drawn the reader's attention to the fact that, although we may be far behind other countries in our methods, we are trying to do things as best we can. There has been much to bring our rubber planting industry into disrepute. But we are by no means down-hearted, and we feel confident that we shall, some day, be able to do our share in contributing to supply the world with that valuable commodity, rubber. The area now planted will yet be largely increased in Mexico and all through Central America, but I do not think this need cause rubber planters, present or prospective, in other countries any concern. There is plenty of room, and with more rubber produced we will have more articles made from this staple, for the benefit of mankind.

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